LEX LOCALIS-JOURNAL OF LOCAL SELF-GOVERNMENT
ISSN:1581-5374 E-ISSN:1855-363X
VOL. 21, NO. S1 (2023)

MACROECONOMIC DETERMINANTS OF GOVERNMENT SECURITIES YIELD: A STUDY OF INDIAN GOVERNMENT SECURITIES MARKET

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Abstract

The objective of the paper is to study the impact of macroeconomic variables such as debt to GDP ratio, output growth, inflation, monetary policy, ten-year benchmark US treasury yield, LIBOR, and exchange rate on short, medium, and long-term government securities (G-Secs) yields. VAR model and Impulse Response are used for analysis. The study has used data from January 1997 to December 2017. Results show that inflation and monetary policy are the most important macroeconomic determinants of G-Secs yield. It is also found that the impact of monetary policy decreases with the increase in maturity of G-Secs yield. Besides, the exchange rate has a significant effect on only short-term G-Secs yield. Other macroeconomic variables such as debt to GDP, index of industrial production, LIBOR, and ten-year benchmark US treasury yield have no significant impact on the G-Secs yield of any maturity in Indian G-Secs market.

Keywords: Government Securities Yield, Inflation, Monetary Policy.
JEL Classification Code: E430, E440

1. Introduction

The market of government securities has grown considerably in both developed and emerging economies (Mihaljek et al., 2002; Bank for International Settlements, 2007; Burger et al.,2010). However, the Indian bond market with respect to liquidity is lagging the developed countries and its Asian peers. Nevertheless, the Indian bond market has shown increasing trend from 21.3% of gross domestic product (GDP) in 1996 to 43.0% of GDP in March 2014 (Sabnavis & Mehta, 2014), to 67.0% of GDP in April 2020 (Sridharan, 2020). Reserve Bank of India (RBI) on behalf of the government, issues short, medium, and long-term G-Secs to finance the fiscal deficit (RBI n. d.). The maturity of these G-Secs ranges from fifteen days to thirty years. In India, G-Secs having maturity less than one year are known as treasury bills, and G-Secs having maturity more than one year are known as dated G-Sec. Empirical research on the G-Secs market is attracting significant attention among researchers for the last three decades. Studies conducted in the G-Secs market investigated varied macroeconomic variables such as debt to GDP ratio (Alexander & Anker, 1997; Lemmen & Goodhart, 1999; Copeland & Jones, 2001; Codogno et al. 2003; Bernoth et al. 2004; and Baldacci & Kumar 2010), GDP growth (Afonso, 2009; Thomas & Williams, 2003) and inflation (Fisher, 1930; Taylor, 1993 and Mishkin & Simon 1995) that affect interest rates in the economy. The ability of a country to pay back its debt is measured by the debt to GDP ratio, and studies found direct relationship between debt to GDP and the risk of default (Manasse et al., 2003 and Engen & Hubbard, 2004). According to Manasse et al. (2003) and Engen & Hubbard (2004), government debt may affect real bond yield because of two main reasons. First, an increase in debt increases the default risk premium, which increases the G-Secs yield. Second, with the increase in federal government debt, the marginal product of the capital increase, which increases the G-Secs yield. Both reasons imply a long-run positive association between real bond yield and government debt. Also, large debt induces credit risk premium and decreases the capacity of the government to repay the debt, particularly if growth decreases. Higher inflation expectations due to the deficit financing to fund the large budget deficit also increases the G-Secs yield. Numbers of empirical studies have confirmed a positive relationship between G-Secs yield and the level of government debt. For example, Alesina et al. (1992) analysed yield differentials between the public and private bond yield of twelve OECD countries and showed that the yield is directly related to the level of public debt.

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DOI: https://doi.org/10.52152/bghgrb36

Lemmen (1999) found that the yield spread of bonds issued by state governments in Germany, Australia, and Canada are positively related to government debt to GDP ratio. Further, Baldacci and Kumar (2010) established a direct relationship between the public debt and long-term domestic bond yields in both advanced and emerging markets. However, the literature is scarce on the emerging economies. Recently, Akram and Das (2019) found that the debt ratio of the Indian government has no significant impact on the Indian G-Secs yield over the long run.

Economic theory documents that an increase in real GDP increases the average interest rate in an economy (Thomas & Williams, 2003). Thomas and Williams (2003) remarked that higher economic growth increases the real interest rate through two key channels. First, with the increase in GDP, the return-on-investment increases, which increases the demand for investment. Second, households increase their consumption and reduce their savings in anticipation of an increase in future earnings. Hence, higher investment demand and lower savings increase the real interest rate. Thomas and Williams (2003) also stated that economic growth increases the demand for transaction money and money required to finance the projects, which again increases the interest rate in the economy. Their study was focused on the USA economy. Other empirical studies confirmed that rapidly growing economies pay a higher interest rate. For instance, Afonso (2009) studied the ten-year G-Secs yield for fourteen EU countries and found that yields are directly related to the better growth forecasts and inversely related to the budget balance-to-GDP ratios. Afonso (2009) also stated that higher interest rates in the economy increase the yield and decrease the price of the G-Secs.

Inflation is another major factor affecting G-Secs yield. Mishkin and Simon (1995) found a direct relationship between long-run interest rates and inflation in the Australian economy. The scholars remarked that with the increase in inflation in the economy, the nominal interest rate increases, which increases the yield on the G-Secs. They also stated that this relationship majorly exists in high inflation countries. It is observed that central bank in a high inflation country generally applies tight monetary policy to reduce inflation, which increases the yield on the G-Secs. The seminal contributions by Fisher (1930) and Taylor (1993), which relate inflation with interest rates, are worth to be noted. Fisher's effect by Fisher postulates that nominal interest rates in any period are equal to real interest rates and inflation. He established that there exists one-to-one relationship between inflation and interest rates. And the real rate in the economy is determined by the productivity of capital and investor's time preference. The relationship between the interest rate and inflation is also examined by Taylor (1993) and is widely recognized and known as Taylor's Rule.

Evans and Marshall (1998), in their study, established significant effects of monetary policy on short-term interest rates. They used the vector autoregression (VAR) model to explain movement of the YC by the monetary policy, economic activity, and inflation. In 2007, in their extended study, Evans and Marshall found little evidence that the fiscal policy affects the interest rate variability. Afonso and Martins (2010) also support significant impact of monetary policy on interest rates in the German market. Kapur et. al. (2018) found that the policy rate is the key driver of the G-Secs yield in India and found that with the increase in maturity of the G-Secs yield, the impact of the policy rate weakens.

In addition to debt to GDP ratio, inflation, output growth and inflation, international factors like LIBOR (London Interbank Offered Rate) exchange rate, and US T-bills (treasury bills) are equally important to know how they affect G-Secs yield. It is well documented in the literature that fluctuation in LIBOR affects the cost of borrowing of corporations since they borrow from international markets. Though the interest rate that the corporations pay on the external commercial borrowings is tied up with the LIBOR, very meagre research is conducted to study the impact of these global benchmarks on Indian G-Secs yield and the determinants underlying the impact.

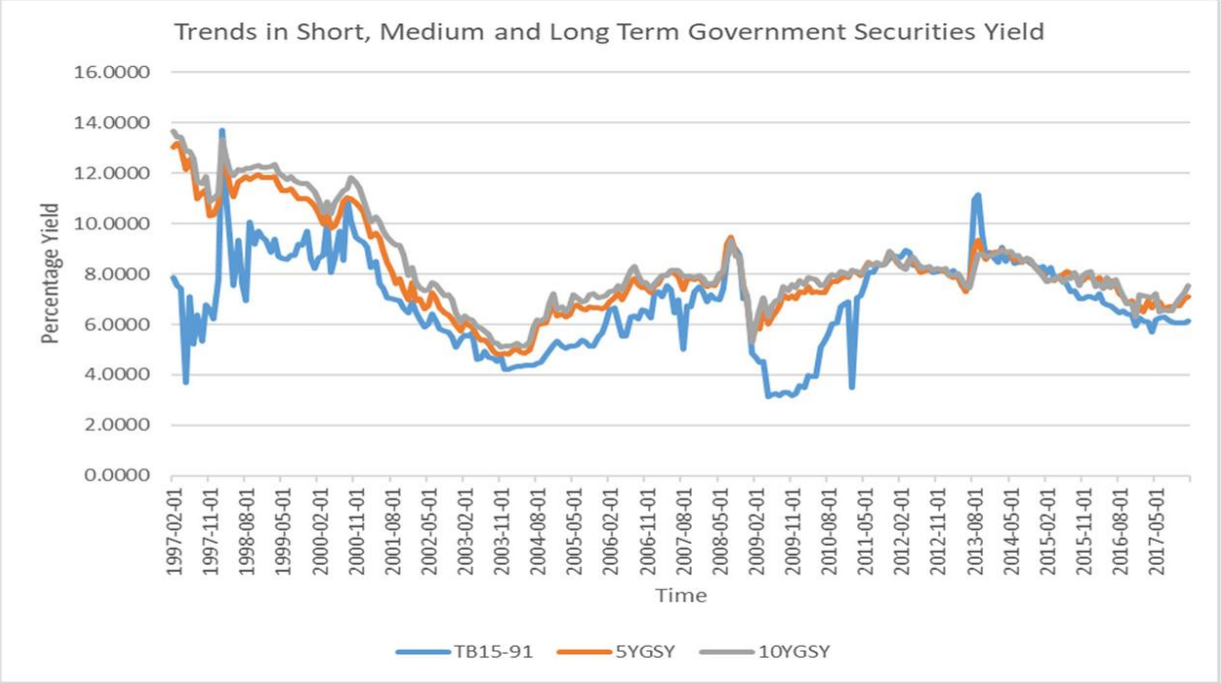
Also, the exchange rate risk is another important factor affecting the local currency bond yield (Gadanecz et al., 2014). Further, it is an established fact that higher exchange rate risk results in higher expected return, and hence, the same effect is assumed on the G-Secs. For example, depreciation in the exchange rate makes imports costly, which increases inflation and consequently affects G-Secs yield (Gagnon 2008). However, research is relatively thin on this determinant.

Thus, the existing literature on the G-Secs market highlights many research gaps. Although considerable research has been devoted to the study of macroeconomic variables on the long-term government yield, the impact of these variables on different maturities of G-Secs such as short-term,

medium-term, and long-term has yet not given significant attention. So far, most of the research has been confined to the impact of macroeconomic variables such as debt to GDP ratio (Manasse et al., (2003); Engen and Hubbard (2004); Alesina et al. (1992); Lemmen (1999); Alexander and Anker (1997); Lemmen and Goodhart (1999); Copeland and Jones (2001); Codogno et al. (2003); Baldacci and Kumar (2010); Akram and Das (2019)), output growth (Thomas and Williams (2003) and Afonso (2009)), monetary policy (Evans and Marshall (1998); Afonso and Martins (2010)); Bernard and Gerlach (1996) and Estrella and Mishkin (1997)), and inflation (Irving Fisher (1930); Mishkin and Simon (1995) and Diebold et al. (2006)) on G-Secs yield. Most of the studies are cantered on either one or two of the variables. Further, most of the studies on macroeconomic variables affecting G-Secs yield employ the US, European, and Organisation for Economic Co-operation and Development (OECD) data (Alesina et al., 1992; Lemmen, 1999 and Bernoth et al. 2004) while, comparatively limited literature exists in context to developing countries.

The objective of this study is to find macroeconomic determinants that explain the fluctuations in the 15-91 days' maturity treasury bill (short-term), five-year (medium-term), and ten-year G-Secs yield (long-term). Indian context, minimal research has been conducted on the impact of the macroeconomic determinants on the short, medium and long-term G-Secs yield. Lastly, most of the studies on G-Secs are conducted in developed markets The yield fluctuations from 1997 to 2017 period in these G-Secs are shown in figure I. It is clear from the figure that the yield on these securities is fluctuating over time.

Figure 1 Trends in Short, Medium, and Long-term Government Securities Yield



Source: Authors' calculations using data from RBI's database on the Indian economy.

Note: TB15-91 (Fifteen -Nineteen days' treasury bills; 5YGSY (Five-year G-Secs yield); 10YYGSY (Ten-year G-Secs yield)

Paper is further divided into four sections: section second deals with methodology, third section explains the results and last section concludes the study.

2. Methodology

To assess how the macroeconomic variables namely debt to GDP ratio, output growth, inflation, and monetary policy, ten-year benchmark US treasury yield, LIBOR, and exchange rate affect the G-Secs yield and to extract factors that best describe the dynamics of various sectors of the economy, Vector Autoregression (VAR) (along with Impulse Function), one of the well-accepted method in the literature

is used (Bernard and Gerlach (1996), Sahoo and Bhattacharyya (2012) Sensarma and Bhattacharyya, (2016), Ahokpossi et al. (2016)).
Frequencies of all the variables are monthly except Debt to GDP ratio, which is converted into monthly from quarterly data using interpolation. The study has used data from January 1997 to December 2017. Types of G-Secs yields, namely 15-91 days' maturity treasury bill yield (TB15_91), five-year G-Secs yield (5YGSY), and ten-year G-Secs yield (10YGSY) are considered as dependent variables. The first difference of 15-91 days' maturity treasury bill yield, five-year G-Secs yield, and ten-year G-Secs yield are represented by DTB15_91, D5YGSY, and D10YGSY respectively. Debt to GDP, index of industrial production (as a proxy for output growth), crude oil prices (as a proxy for inflation), bank rate as monetary policy variable, Indian rupees per US dollar exchange rate, LIBOR, and ten-year benchmark US treasury yield are used as independent variables. The first difference of debt to GDP ratio, index of industrial production (IIP), crude oil prices, bank rate, ten-year benchmark US treasury yield, LIBOR, and Indian rupees per US dollar exchange rates are represented by DTB15_91, D5YGSY, D10YGSY, DD_GDP, DLN_IIP, DCRUDE_OIL_WTI, DBANK_RATE, DTRUS10T DLIBOR12_M, and DUSDINR, respectively.

2.1. Stationarity of the Variables

Vector Autoregression (VAR) model and Impulse Response function are used for the analysis. Before applying the VAR model, the stationarity of all the data variables are tested. Augmented Dickey-Fuller (ADF) test for the presence of the unit root is used to test the stationarity of the data variables. Variables that record significant t-statistics indicate that time series is stationary. Thereafter, the first difference of the variables is calculated for such non-stationary variables. All variables generally are found to be stationary after the first difference, and very rarely, researchers have to take the second difference to check stationarity of the series. Further, the lag length selected for the ADF unit root test is based on the Schwarz information criterion (SIC) (Gujarati & Sangeetha, 2007). Based on the ADF test (Table 1), five-year G-Secs yield (5YGSY), ten-year G-Secs yield (10YGSY), and determinants namely debt to GDP ratio (D_GDP), ten-year benchmark US treasury yield (TRUS10T), London interbank offer rate (LIBOR12_M), Indian rupees per US dollar exchange rate (USDINR) and crude oil prices (CRUDE_OIL_WTI) establish stationarity after first difference. At the same time,15-91 days' maturity treasury bill yield (TB15_91), the log of the index of industrial production (LN_IIP), and bank rate (BANK_RATE) are stationary at the level only.

Table 1: Stationarity of Variables (G-Secs Yield)

S. No	Variables	Level			First Difference			Remarks
		Lag Length	t-Statistic	Prob.	Lag Length	t-Statistic	Prob.	
1	TB15_91	1	-3.00	0.04	Not Required			Stationary at the level
2	5YGSY	0	-2.63	0.09	0	-15.15	0.00	Stationary after first difference
3	10YGSY	0	-2.71	0.07	0	-10.26	0.00	Stationary after first difference
4	D_GDP	15	-0.58	0.87	15	-4.00	0.00	Stationary after first difference
5	LN_IIP	1	-3.94	0.00	Not Required			Stationary at the level
6	CRUDE_OIL_WTI	0	-1.77	0.39	0	-14.12	0.00	Stationary after first difference
7	BANK_RATE	0	-3.42	0.01	Not Required			Stationary at the level
8	TRUS10T	0	-1.87	0.35	0	-13.23	0.00	Stationary after first difference

9	**LIBOR12_M**	1	-1.56	0.50	0	-11.12	0.00	Stationary after first difference
10	**USDINR**	1	-0.95	0.77	0	-11.57	0.00	Stationary after first difference
Source: Authors' calculations using data from RBI's DBIE								
Note: TB15_91 (15-91 days' maturity treasury bill yield), 5YGSY (five-year G-Secs yield), 10YGSY (ten-year G-Secs yield), D_GDP (debt to GDP ratio), LN_IIP (Index of industrial production), CRUDE_OIL_WTI (crude oil prices), BANK_RATE (Bank rate), TRUS10T (Ten-year benchmark US treasury yield), LIBOR12_M (London interbank offer rate), USDINR (Indian rupee per US dollar exchange rate)								

3. Results and Discussion

3.1. Descriptive Statistics

Descriptive statistics of dependent and independent variables are given in table 2. The table shows that standard deviation is maximum in ten-year G-Secs yield and minimum in the three months' treasury bill yield, indicating that risk in the long-term is higher than short-term G-Secs. The statistics also reveal that the mean yield increases with the G-Secs maturity, showing that the average yield curve is upward sloping in the Indian economy. In the case of independent variables, descriptive statistics of crude oil shows that the mean crude oil price is $ 55.80. The standard deviation of the same is 29.76, which indicates very high fluctuations in crude oil. The table also shows that the standard deviation of bank rate and ten-year benchmark US treasury yield are almost the same, but the average of these variables is different by around three percentage points. Similarly, table II shows the descriptive statistics of the rest independent variables.

Table 2: Descriptive Statistics of G-Secs Yield

S. No	Variables	Average	Median	Max	Min	Std. Dev.	Observations
1	**TB15_91**	6.92	6.99	13.70	3.12	1.79	252
2	**5YGSY**	8.12	7.80	13.17	4.81	1.87	252
3	**10YGSY**	8.40	7.92	13.66	5.11	1.94	252
4	**D_GDP**	53.09	52.12	64.49	44.48	5.43	252
5	**LN_IIP**	5.82	5.10	23.68	-7.52	4.50	252
6	**CRUDE_OIL_WTI**	55.80	50.94	145.31	11.20	29.76	252
7	**BANK_RATE**	7.21	6.50	12.00	6.00	1.43	252
8	**TRUS10T**	3.82	3.90	6.88	1.46	1.42	252
9	**LIBOR12_M**	2.90	2.00	7.45	0.54	2.10	252
10	**USDINR**	49.42	46.53	68.24	35.74	8.66	252
Source: Authors' calculations using data from RBI's database on the Indian economy. **Note:** TB15_91 (15-91 days' maturity treasury bill yield), 5YGSY (five-year G-Secs yield), 10YGSY (ten-year G-Secs yield), D_GDP (debt to GDP ratio), LN_IIP (Index of industrial production), CRUDE_OIL_WTI (crude oil prices), BANK_RATE (Bank rate), TRUS10T (Ten-year benchmark US treasury yield), LIBOR12_M (London interbank offer rate), USDINR (Indian rupee per US dollar exchange rate)							

3.2. Determinants of Short-Term G-Secs Yield

After establishing the stationarity of the variables, either at the level or after the first difference, the impact of macroeconomic variables on yields of G-Secs is examined.

Schwarz information criterion (SIC) is used to determine the VAR model's lag structure for the short-term G-Secs yield. SIC suggests two lags for running the VAR model. The results of the VAR lag order selection criteria are shown in table 3.

Table 3 VAR Lag Order Selection of Short-Term G-Secs Yield

S.No	Lag	Log L	L.R.	F.P.E.	A.I.C.	S.I.C.	H.Q.
1	0	-2678.702	NA	0.506177	22.02215	22.13681	22.06833
2	1	-1986.490	1333.360	0.002938	16.87287	17.90482	17.28848
3	2	-1750.211	439.6326	0.000717	15.46075	17.40999*	16.24579
4	3	-1610.262	251.2209	0.000386	14.83821	17.70474	15.99269*
5	4	-1545.347	112.2697	0.000386	14.83072	18.61454	16.35463
6	5	-1480.261	108.2995	0.000388	14.82181	19.52292	16.71516
7	6	-1391.710	141.5359	0.000323	14.62058	20.23898	16.88336
8	7	-1312.954	120.7161*	0.000294*	14.49963*	21.03532	17.13184
9	8	-1280.137	48.15087	0.000393	14.75522	22.20820	17.75687

Endogenous variables: TB15_91 (15-91 days' maturity treasury bill yield), DD_GDP (First difference of debt to GDP ratio), LN_IIP (Index of industrial production), DCRUDE_OIL_WTI (First difference of crude oil prices), BANK_RATE (Bank rate), DTRUS10T (First difference of Ten-year benchmark US treasury yield), DLIBOR12_M (First difference of London interbank offer rate), DUSDINR (First difference of Indian rupee per US dollar exchange rate)
Exogenous variables: C
* indicates lag order selected by the criterion
"Final prediction error (F.P.E); Sequential modified Likelihood Ratio (L.R.) test statistic (each test at 5% level); Akaike information criterion (A.I.C.); Schwarz information criterion (S.I.C.); Hannan-Quinn information criterion (H.Q.)".

The details of the lag structure, VAR estimates, and Impulse Response of short-term G-Secs yield are discussed as under:

3.2.1. Vector Autoregression Estimates

Table 4shows the summary of the VAR estimates of short-term G-Secs as a dependent variable. The results depict that 15-91 days' maturity treasury bill yield (TB15_91) significantly affects itself after one and two months, but its effect decreases over time. The second most crucial macroeconomic variable affecting the short-term yield is the bank rate. The results show that bank rate, i.e., monetary policy, has a significant positive impact after one month and a significant negative impact after two months on short-term G-Secs yield. The positive impact and then thereafter negative effect maybe because with the increase in bank rate (i.e., tight monetary policy), the short-term yield increases in the first instance and after two months, with the rise in interest rate, the economic growth and inflation decreases which consequently decreases the short-

Table 4 Summary of VAR Estimates of Short-term G-Secs Yield

Lags of IV	Coefficient	Standard errors	t-statistics	Lags of IV	Coefficient	Standard errors	t-statistics
TB15_91(-1)	0.55	0.06	9.58	**BANK_RATE(-1)**	1.07	0.14	7.84
TB15_91(-2)	0.31	0.06	5.37	**BANK_RATE \ (-2)**	-0.92	0.13	-6.90
DD_GDP (-1)	-0.22	0.20	-1.07	**DTRUS10T(-1)**	-0.27	0.21	-1.28
DD_GDP(-2)	0.04	0.21	0.21	**DTRUS10T(-2)**	0.05	0.21	0.25
LN_IIP(-1)	0.0	0.02	0.17	**DLIBOR12_M(-1)**	0.03	0.27	0.11
LN_IIP(-2)	0.02	0.02	1.46	**DLIBOR12_M(-2)**	-0.09	0.27	-0.33
DCRUDE_OIL_WTI(-1)	0.02	0.01	2.23	**DUSDINR(-1)**	0.12	0.06	1.87

DCRUDE_ OIL_WTI(-2)	0.02	0.01	1.87	**DUSDINR(-2)**	0.02	0.06	0.39

Source: Authors' Calculations
T-statistics more than 2 is considered significant; IV: Independent Variable
Variables: TB15_91 (15-91 days' maturity treasury bill yield), DD_GDP (First difference of debt to GDP ratio), LN_IIP (Index of industrial production), DCRUDE_OIL_WTI (First difference of crude oil prices), BANK_RATE (Bank rate), DTRUS10T (First difference of Ten-year benchmark US treasury yield), DLIBOR12_M (First difference of London interbank offer rate), DUSDINR (First difference of Indian rupee per US dollar exchange rate)
(-1): First lag ; (-2): Second lag

term G-Secs yield. Inflation is established as the third most important macroeconomic variable, which has a significant impact after one month i.e., after one lag. This may be because with the increase in inflation, the nominal interest rate increases with one-month lag, and thereafter after one month, the impact becomes insignificant. Table IV also shows that other macroeconomic variables such as debt to GDP ratio, index of industrial production, ten-year benchmark US treasury yield, LIBOR, and Indian rupee per US dollar exchange rate do not have significant impact on the short-term G-Secs yield. Hence, the results suggest that monetary policy, inflation, and short-term yield itself have significant effect on the short-term G-Secs yield.

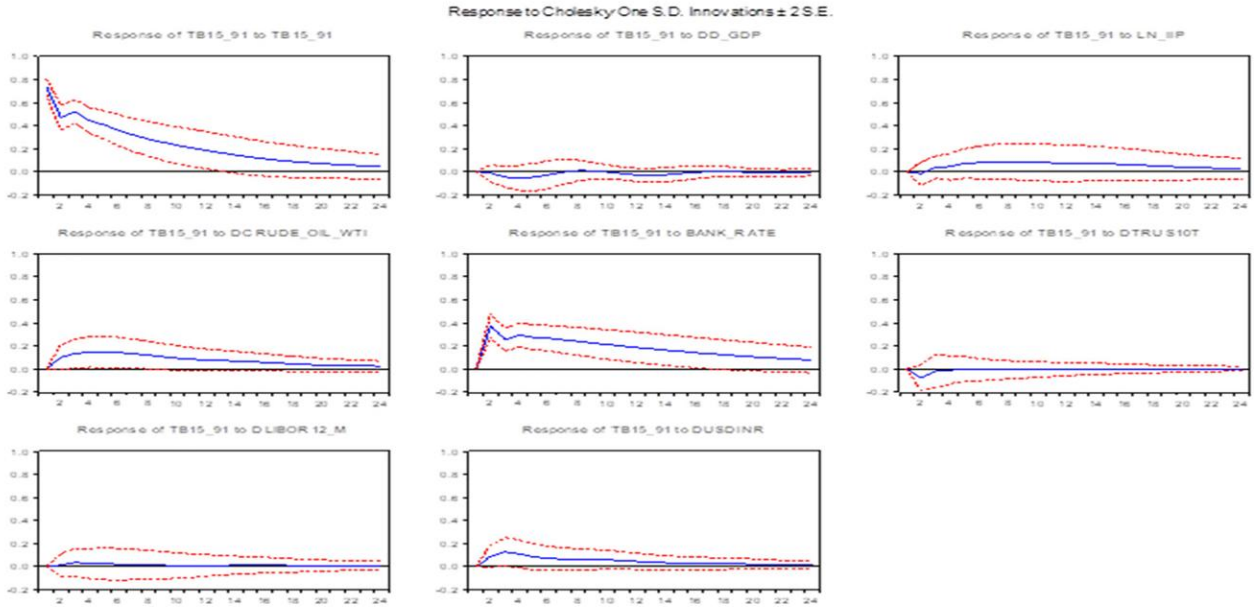
3.2.2. Impulse Response

Literature documents that one of the most significant limitations of the VAR model is its interpretation. Mainly, a large number of parameters are involved, and lag variables also occasionally change signs, making it extremely challenging to see how the variables affect future values given a change in the values of the variables (Brooks, 2008). To reduce the conundrum, the literature suggests using Impulse Responses of the estimated VAR model (Brooks, 2008).

The Impulse Response captures the dynamic relationship between the short-term G-Secs yield and macroeconomic variables with one-unit shock in the residual. If the Impulse Response function's error confidence band is either above or below the horizontal axis and does not cross the horizontal axis, the response in such a case, is then is significantly different from zero (Djuranovik, 2014). In Impulse Response, the one-unit shock is given to VAR variables to see how the variables behave over time. These Impulse Response functions are plotted on a graph to see whether the impact of the shock increases or decreases over twenty-four period time, based on the +2 standard error confidence band (Figure 2), which is the confidence interval over the point estimate.

Impulse Response function shows that the impact of short-term yield, crude oil prices, bank rate, and exchange rates is significant for about twelve months, eight months, fifteen months, and three months respectively. Thereafter, these macroeconomic variables have an insignificant impact. It also shows that these macroeconomic variables have a significant positive impact on short-term G-Secs yield, which means that in the Indian economy, the increase in inflation, bank rate, and exchange rate increases the short-term yield. Further, the other macroeconomic variables, namely debt to GDP ratio, index of industrial production, ten-year benchmark US treasury yield, and LIBOR, do not significantly impact the short-term G-Secs yield (figure II).

Figure 2 Impulse Response of Short-term G-Secs Yield



Source: Authors' Calculations

3.3. Determinants of Medium-Term G-Secs Yield

Similarly to the short-term G-Secs procedure, the lag structure is examined before applying VAR and Impulse Response. Table 5 suggests that two lags be included in the VAR equation for medium-term G-Secs yield.

Table 5 VAR Lag Order Selection Medium-term G-Secs Yield

S. No.	Lag	Log L	L.R.	F.P.E.	A.I.C.	S.I.C.	H.Q.
1	0	-2358.913	NA	0.036806	19.40092	19.51558	19.44710
2	1	-1786.406	1102.778	0.000570	15.23284	16.26479	15.64845
3	2	-1540.203	458.1002	0.000128	13.73937	15.68861*	14.52441
4	3	-1404.503	243.5920	7.15e-05	13.15167	16.01820	14.30615*
5	4	-1336.913	116.8973	7.00e-05	13.12224	16.90606	14.64615
6	5	-1273.538	105.4525	7.12e-05	13.12736	17.82847	15.02071
7	6	-1181.029	147.8626	5.74e-05	12.89368	18.51208	15.15646
8	7	-1111.273	106.9214*	5.62e-05*	12.84650*	19.38219	15.47871
9	8	-1071.577	58.24245	7.11e-05	13.04571	20.49869	16.04736

Endogenous variables: 5YGSY (Five-year G-Secs yield), DD_GDP (First difference of debt to GDP ratio), LN_IIP (Index of industrial production), DCRUDE_OIL_WTI (First difference of crude oil prices), BANK_RATE (Bank rate), DTRUS10T (First difference of Ten-year benchmark US treasury yield), DLIBOR12_M (First difference of London interbank offer rate), DUSDINR (First difference of Indian rupee per US dollar exchange rate)
Exogenous variables: C

* indicates lag order selected by the criterion

3.3.1. Vector Autoregression Estimates of Medium-term G-Secs Yield

Summary of VAR estimates with two lags is given in table 6. The result indicates that bank rate and crude oil prices are the most important variables affecting the five-year G-Secs yield. Rest other macro-economic variables, namely debt to GDP ratio, output growth, ten-year benchmark US treasury yield, LIBOR, and exchange rate, in VAR estimates, have no significant impact. Specifically, bank rate has a significant positive effect after one month and a significant negative effect after two months. This is similar to the impact of monetary policy on short-term G-Secs yield. On the other hand, crude oil price has a significant positive effect, but the effect decreases in magnitude after the first month.

Table 6 Summary of the VAR estimates Medium-term G-Secs Yield

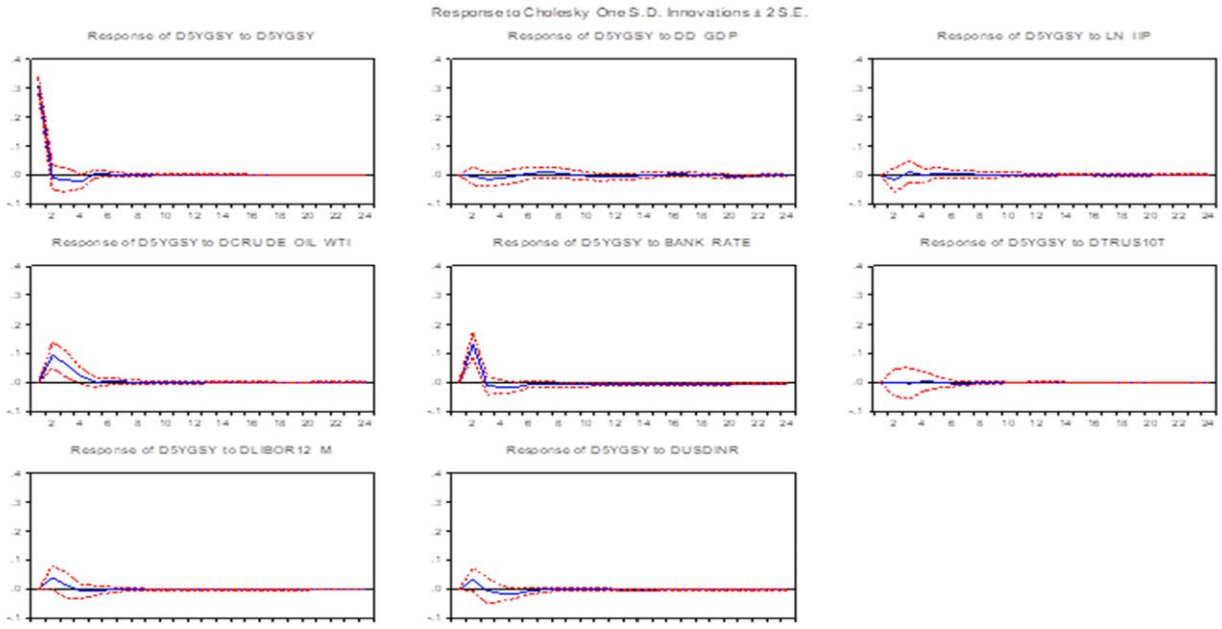
Lags of IV	Coefficient	Standard errors	t-statistics	Lags of IV	Coefficient	Standard errors	t-statistics
D5YGSY(-1)	-0.12	-0.06	-1.98	**BANK_RATE(-1)**	0.39	-0.06	6.81
D5YGSY(-2)	-0.06	-0.06	-1.11	**BANK_RATE(-2)**	-0.39	-0.06	-7.00
DD_GDP(-1)	-0.05	-0.09	-0.59	**DTRUS10T(-1)**	-0.04	-0.09	-0.47
DD_GDP(-2)	-0.01	-0.09	-0.09	**DTRUS10T(-2)**	-0.04	-0.09	-0.44
LN_IIP(-1)	-0.01	-0.01	-1.12	**DLIBOR12_M(-1)**	0.21	-0.12	1.83
LN_IIP(-2)	0.01	-0.01	1.17	**DLIBOR12_M(-2)**	-0.02	-0.11	-0.14
DCRUDE_OIL_WTI(-1)	0.02	0.00	4.53	**DUSDINR(-1)**	0.04	-0.03	1.69
DCRUDE_OIL_WTI(-2)	0.01	0.00	3.34	**DUSDINR(-2)**	-0.03	-0.03	-1.10

Source: Authors' Calculations
T-statistics more than 2 is considered significant; IV: Independent Variable
Variables: D5YGSY (Five-year G-Secs yield), DD_GDP (First difference of debt to GDP ratio), LN_IIP (Index of industrial production), DCRUDE_OIL_WTI (First difference of crude oil prices), BANK_RATE (Bank rate), DTRUS10T (First difference of Ten-year benchmark US treasury yield), DLIBOR12_M (First difference of London interbank offer rate), DUSDINR (First difference of Indian rupee per US dollar exchange rate)
(-1): First lag; (-2): Second lag

3.3.2. Impulse Response

Figure 3 shows the five-year G-Secs yield's Impulse Response functions for twenty-four months horizon using +2 standard error confidence band. Impulse Response function shows that crude oil prices' response is significant for about first five months; bank rate for three months; and medium-term yield itself for two months. However, after that the impact decreases and becomes insignificant. While the response to the rest of the other variables is not significant. The figure also shows that all these macroeconomic variables have a significant positive impact on the medium-term yield, which means that with the increase in crude oil prices, and bank rate medium-term yield increases.

Figure 3 Impulse Response of Medium-term G-Secs Yield



Source: Authors' Calculations

3.4. Determinants of Long-Term G-Secs Yield

Akin short-term and medium-term government security yields, SIC is used to decide the long-term government security yield model's lag length. The VAR lag order selection criteria are presented in table 7. As per the SIC criterion, the optimum lag length for VAR estimation is two lags.

Table 7 VAR Lag Order Selection Long-Term G-Secs Yield

S. No.	Lag	Log L	L.R.	F.P.E.	A.I.C.	S.I.C.	H.Q.
1	0	-2361.6	NA	0.037620	19.42281	19.53747	19.46899
2	1	-1788.6	1103.623	0.000581	15.25113	16.28308	15.66674
3	2	-1555.4	433.9497	0.000145	13.86405	15.81329*	14.64909
4	3	-1420.5	242.2508	8.15e-05	13.28247	16.14900	14.43695*
5	4	-1349.1	123.3619	7.73e-05	13.22241	17.00623	14.74632
6	5	-1284.7	107.2394	7.80e-05	13.21872	17.91984	15.11207
7	6	-1188.2	154.2536	6.09e-05*	12.95227	18.57067	15.21505
8	7	-1122.5	100.6131*	6.17e-05	12.93882*	19.47451	15.57104
9	8	-1086.7	52.53111	8.05e-05	13.16994	20.62292	16.17159

Endogenous variables: D10YGSY (ten-year benchmark G-Secs yield), DD_GDP (First difference of debt to GDP ratio), LN_IIP (Index of industrial production), DCRUDE_OIL_WTI (First difference of crude oil prices), BANK_RATE (Bank rate), DTRUS10T (First difference of Ten-year benchmark US treasury yield), DLIBOR12_M (First difference of London interbank offer rate), DUSDINR (First difference of Indian rupee per US dollar exchange rate)
Exogenous variables: C
* indicates lag order selected by the criterion

3.4.1. Vector Autoregression Estimates of Long-term G-Secs Yield

Results of VAR estimates (Table 8) depict that ten-year benchmark US treasury, bank rate, and crude oil prices are the most persistent components affecting the ten-year G-Secs yield. These results are similar to the effects of medium-term G-Secs yield.

Table 8 Summary of the VAR estimates Long-term G-Secs Yield

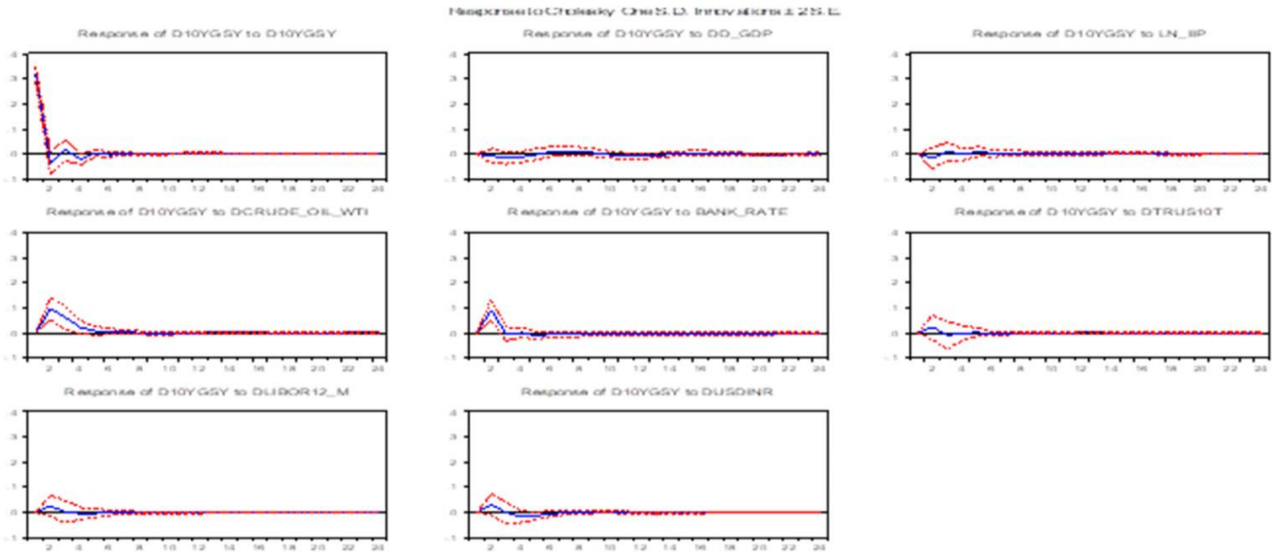
Lags of IV	Coefficient	Standard errors	t-statistics	Lags of IV	Coefficient	Standard errors	t-statistics
D10YGSY(-1)	-0.16	-0.06	-2.55	**BANK_RATE(-1)**	0.27	-0.06	4.59
D10YGSY(-2)	0.00	-0.06	0.07	**BANK_RATE(-2)**	-0.27	-0.06	-4.66
DD_GDP(-1)	-0.09	-0.09	-0.98	**DTRUS10T(-1)**	0.05	-0.09	0.52
DD_GDP(-2)	0.00	-0.09	0.03	**DTRUS10T(-2)**	-0.02	-0.09	-0.26
LN_IIP(-1)	-0.01	-0.01	-1.10	**DLIBOR12_M(-1)**	0.13	-0.12	1.13
LN_IIP(-2)	0.01	-0.01	1.16	**DLIBOR12_M(-2)**	-0.04	-0.11	-0.36
DCRUDE_OIL_WTI(-1)	0.02	0.00	4.32	**DUSDINR(-1)**	0.04	-0.03	1.57
DCRUDE_OIL_WTI(-2)	0.01	0.00	3.28	**DUSDINR(-2)**	-0.01	-0.03	-0.46

Source: Authors' Calculations
T-statistics more than 2 is considered significant; IV: Independent Variable
Variables: D10YGSY (Ten-year benchmark G-Secs yield), DD_GDP (First difference of debt to GDP ratio), LN_IIP (Index of industrial production), DCRUDE_OIL_WTI (First difference of crude oil prices), BANK_RATE (Bank rate), DTRUS10T (First difference of Ten-year benchmark US treasury yield), DLIBOR12_M (First difference of London interbank offer rate), DUSDINR (First difference of Indian rupee per US dollar exchange rate)
(-1): First lag; (-2): Second lag

3.4.2. Impulse Response of Long-term G-Secs Yield

The Impulse Response functions reflect that response of ten-year G-Secs yield to crude oil prices and the bank rate are significant for five months and three months respectively (Figure IV). This indicates that only inflation and monetary policy significantly impact the long-term G-Secs yield, and with the increase in inflation and bank rate, long-term yield increases. Also, long-term yield significantly impacts itself for one lag only. VAR results also confirm these results.

Figure 4 Impulse Response of Long-term G-Secs Yield



Soruce: Authors' Calculations

4. Conclusion

This paper aims to study the impact of macroeconomic variables namely debt to GDP ratio, output growth, inflation, and monetary policy, ten-year benchmark US treasury yield, LIBOR, and exchange rate on short, medium, and long-term G-Secs yields. VAR model and Impulse Response is used for analysis. Among various macro determinants, inflation, bank rate and exchange rate are considered as significant indicators that impact the G-Sec yields. Inflation has emerged as one of the significant macroeconomic variables affecting all maturities' G-Secs yield. VAR estimates show that inflation positively impacts short-term G-Secs yield after first lag and medium and long-term G-Secs yield after first lag and second lag, respectively. Results also reveal that impact increases with an increase in maturity. The study results support the findings of researchers like Mishkin and Simon (1995) and Prasanna (2018) who found positive relationship between long-run interest rates and inflation in the Australian economy Indian economy respectively. The results are substantial both in the case of VAR and Impulse Response in the Indian economy. Bank rate, i.e., monetary policy variable, is the second other crucial macroeconomic variable that has significant impact on yields of all the three maturities under consideration. Results show that impact decreases with the increase in maturity, i.e., monetary policy has the highest impact on the short-term yield, followed by medium and long-term yields. These results are consistent with the literature as well in both developed and developing economy. For instance, Evans and Marshall (1998) and Afonso and Martins (2010) found that short-term interest rates are significantly affected by the monetary policy in the developed economies. Whereas Subramaniam and Prasanna (2018) and Kapur et al. (2018) found in context to Indian economy and stated that as G-Secs yield increase in maturity, the impact of the policy rate weakens. The exchange rate, i.e., INR/USD, partially affects G-Sec yield. That is, it has significant impact on short-term yield shown by Impulse Response but no impact on medium and long-term G-Secs yield. There may be two reasons for these results. First, the exchange rate may have an impact on the investments by international institutional investors. However, the share of these investors is low in the Indian G-Secs market (RBI n. d.). Second, the Indian government issues bonds in the domestic market denominated in Indian rupees. The rest other determinants do not have significant impact on the G-Sec yields.

Debt to GDP ratio, which is an indicator of the country's financial strength, shows no significant impact on any of the yields, which is contrary to the results of previous research such as Alesina et al. (1992)

and Lemmen (1999). Both these studies found positive relationship between public debt and yield in developed countries like Australia, Canada, and Germany. Similarly, studies, namely Alexander and Anker (1997), Lemmen and Goodhart (1999), Copeland and Jones (2001), and Codogno et al. (2003) confirmed a positive relationship between public debt and interest rates. This study established that the debt to GDP ratio has no significant impact on the Indian G-Secs yield. This may be because factors like inflation and monetary policy dominate the Indian economy more than the debt to GDP ratio. However, these results support the findings of Akram and Das (2019) , who also found no significant impact of debt to GDP ratio on G-Secs yield in the Indian economy. Similarly, output growth has no significant effect on short, medium, and long-term G-Secs yield. This may be because the output growth does not increase the demand for money in the Indian economy, and hence has no significant impact on G-Secs yield. However Thomas and Williams (2003), Afonso (2009), and Subramaniam and Prasanna (2018) establish positive relationship between output growth and yield in economies such as USA, Germany, and Asia. Two indicators of international interest rate namely ten-year US treasury yield and LIBOR, also do not have significant impact on the Indian G-Secs yield on any type of maturity.

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